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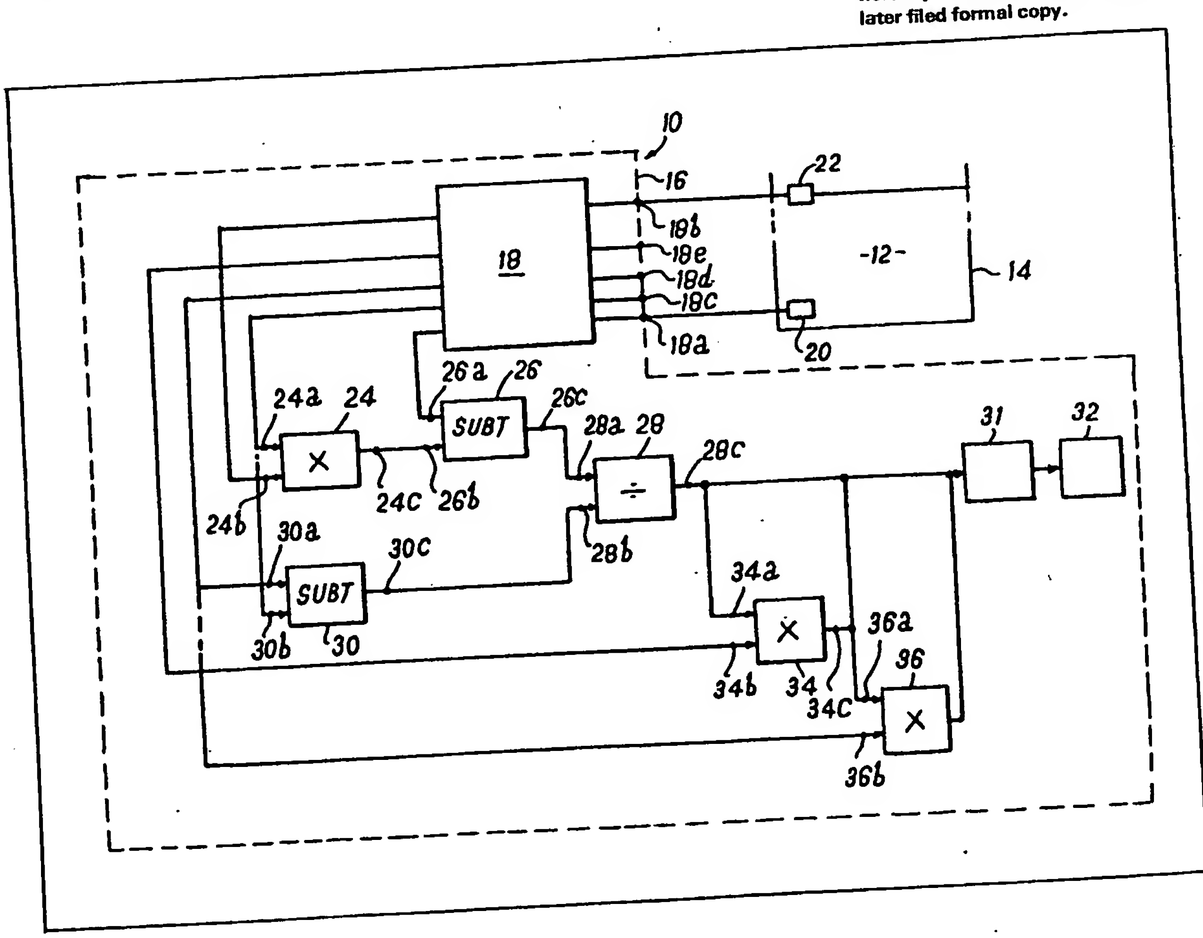
(54) **Method and apparatus for determining the amount of one liquid in the presence of another liquid**

(57) The Specification describes a method of determining a value dependent upon the amount of a first liquid such as oil in a container in the presence of a second liquid such as water having a different relative density. The method comprises the determination of electrical quantities dependent upon the pressure 20 at or near the bottom of the container due to the liquids, the total depth 22 of the liquids and their densities and using electrical calculating apparatus to calculate the height of the said first liquid from the said determined quantities. The volume of the said one liquid can then be calculated from its height and an electrical quantity dependent upon the area of the contained liquid. The mass of said first liquid can then be calculated from its density and the calculated value of its volume. The Specification also describes an apparatus for carrying out the method.

The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.



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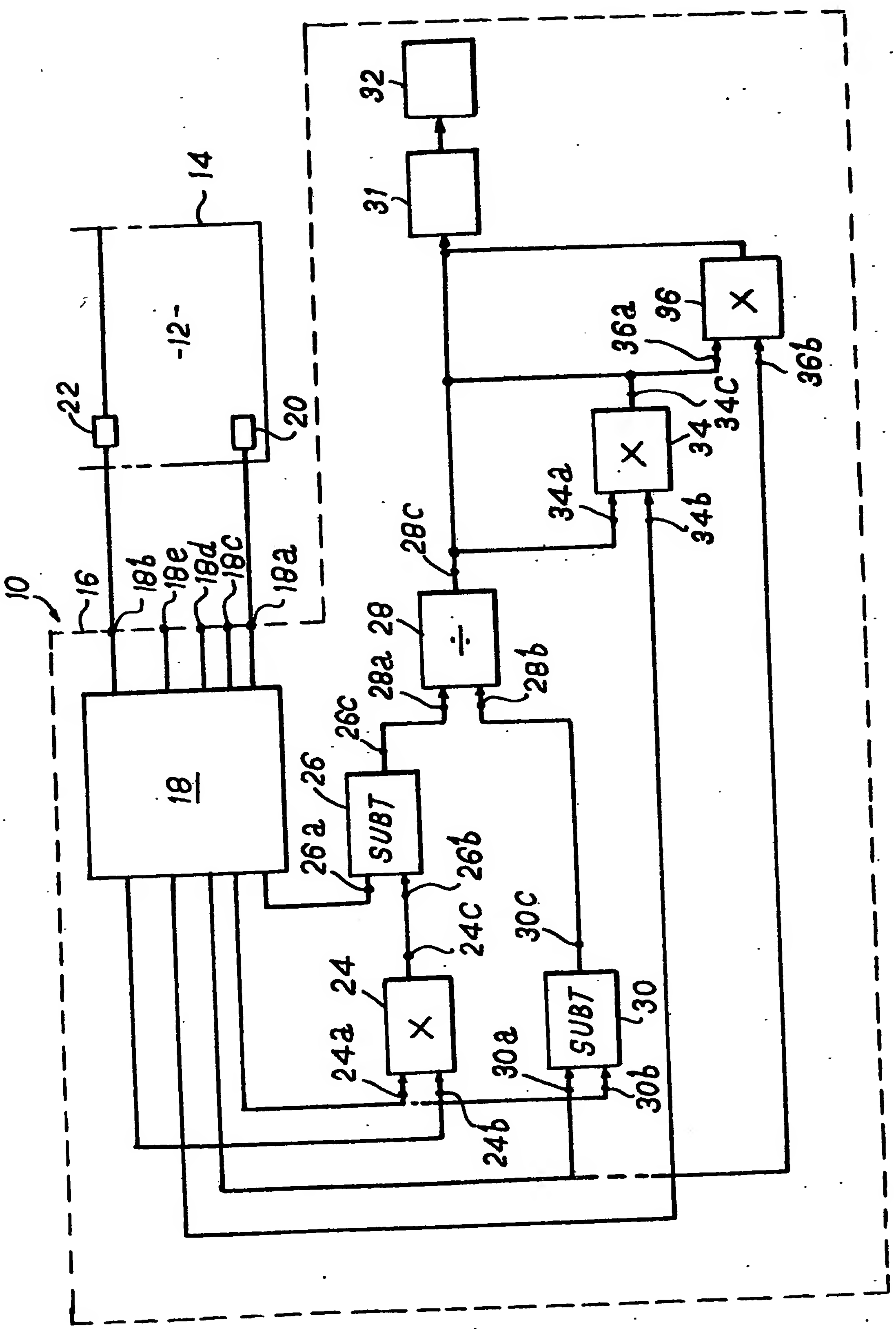
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SPECIFICATION

Method and apparatus for determining the amount of one liquid in the presence of another liquid

This invention relates to a method of, and apparatus for, determining a value dependent upon the quantity of a liquid in the presence of another, generally immiscible, liquid.

It is known that crude oil can contain a considerable quantity of water and it is important that the customer should be able to determine the relative amounts of oil and water in a consignment so that he can calculate the correct cost of the oil alone.

When crude oil is off loaded from a tanker into a storage tank at a refinery, water will be present in varying amounts throughout the consignment and in order to determine the relevant amounts of oil and water it is necessary to take many samples as the oil is discharged or to take numerous samples from different levels in the tank and then to analyse the samples before the quantity of oil can be determined. This process is time consuming and expensive and requires the services of a skilled technician. Another way of determining the amount of oil in a consignment would be to allow the oil and water to settle out and then measure their heights from which their volumes and masses can be determined. However, it can take a long time and perhaps days for the oil and water to settle out and it is believed that the consignors prefer to agree with the consignees the quantity of oil delivered before the tanker departs.

According to one aspect of the invention there is provided a method of determining a value dependent upon the amount of a first liquid in a container in the presence of a second liquid having a different relative density, the method comprising determining electrical quantities dependent upon the pressure at or near the bottom of the container due to the liquids, the total depth of the liquids and their densities and using electrical calculating apparatus to calculate the height of the said first liquid from the said determined quantities.

The method can further comprise the step of using the apparatus to calculate the volume of the said one liquid from its height and an electrical quantity dependent upon the area of the contained liquid.

The method can further comprise the step of using the apparatus to calculate the mass of said first liquid from its density and the calculated volume of its volume.

According to the invention in another aspect there is provided an apparatus for carrying out the method according to the first aspect of the invention.

The invention will now be described by way of example with reference to the accompanying drawing which shows a simplified block circuit diagram of one embodiment of apparatus for carrying out the method according to the invention.

Referring to the drawing, there is shown apparatus 10 for determining the amount of oil in an oil/water mixture 12 contained in a tank 14.

The apparatus 10 comprises calculating apparatus shown within a broken line 16, such as a microprocessor type PM16 sold by Bell & Howell Limited, arranged to determine the effective depth of oil in the mixture 12, that is the depth the oil would reach if the oil and water had been allowed to settle out. The apparatus 16 is shown quite simply with blocks to indicate the functions, such as multiply divide and subtract, which it has to perform as there are many well known ways that such apparatus can be arranged to perform the various functions. As shown, the apparatus comprises a store 18, such as a random access store 18, for storing various input quantities and, if required, intermediate quantities derived during the calculations.

The store 18 has one input 18*a* coupled to receive from a pressure transducer 20 mounted at or near the bottom of the container 14 a digital signal dependent upon the pressure of the mixture 12; a second input 18*b* coupled to receive from a transducer 22 a digital signal dependent upon the depth of the mixture 12 to the transducer 20 and third and fourth inputs 18*c* and 18*d* for receiving digital signals dependent upon the density of the water and oil respectively. If any of the electrical signals representative of pressure, depth or density are in analogue form then it would be necessary to convert them in known manner to digital form by means of an analogue to digital converter.

In the following description of the method, let

h_1 = depth of first liquid I (oil)

h_2 = depth of second liquid II (water)

h_T = total height of both liquids

e_1 = density of first liquid I

e_2 = density of second liquid II

P = pressure

now

$$P = e_1 h_1 + e_2 h_2 \qquad 1.$$

$$H_T = h_1 + h_2 \qquad 2.$$

$$h_2 = h_T - h_1 \qquad 3.$$

$$P = e_1 h_1 + e_2 (h_T - h_1)$$

$$P = h_1 (e_1 - e_2) + e_2 h_T$$

$$h_1 = \frac{P - e_2 h_T}{e_1 - e_2}$$

Thus it is possible to determine the depth of the

oil in the absence of any water. If the area, A of the tank 14 is known then the volume, V and mass, M of the oil can be calculated from

$$V = A.h_1 \qquad \text{and}$$

$$M = V.e_1$$

The method according to the invention can be carried out in the following manner although it is emphasised that the description is somewhat simplified for ease of explanation and in a typical microprocessor apparatus the method might be performed in a quite different manner.

Digital quantities representative of the density, e_2 of the water in the mixture 12 and the depth, h_T of the mixture are coupled to inputs 24*a*, 24*b* respectively of a multiplier circuit 24, the output signal representative of $e_2\,h_T$ and appearing at output 24*c* being coupled to the subtrahend input 26*b* of a subtractor circuit 26. A digital signal representative of the pressure, P of the mixture 12 is coupled to the minuend input 26*a* of the circuit 26 and the output signal representative of the difference $P - e_2\,h_T$ appearing at output 26*c* is coupled to the dividend input 28*a* of a divider circuit 28.

Digital signals representative of the densities e_1 and e_2 of the oil and water are coupled to minuend and subtrahend inputs 30*a*, 30*b* respectively of a subtractor circuit 30 and the output signal representative of $e_1 - e_2$ appearing at output 30*c* is coupled to the divisor input 28*b* of circuit 28. The signal appearing at output 28*c* of the divider circuit 28 is thus equal to

$$\frac{P - e_2\,h_T}{e_1 - e_2}$$

and as shown above this is equal to the effective height h_1 of the oil.

The digital signal representative of the height h_1 of the oil could be decoded in decoder 31 and displayed on a display 32 and/or it could be coupled with a digital signal from store 18 and representative of the area, A of the tank 14 to two inputs 34*a*, 34*b* of a multiplier 34 the output of which is equal to h_T. A which equals the volume V of the oil and this can be displayed on the indicator 32. Furthermore, the output 34*c* of the multiplier 34 could be coupled together with the digital signal representative of the density of the oil to two inputs 36*a* and 36*b* of a further multiplier circuit 36 and the output of the circuit would thus be a signal equal to $V.e_T$ which is equal to the mass, M of the oil in the container 14. The mass, M could be indicated on indicator 32. Alternatively, the mass of the oil can be determined by determining the total mass of the mixture by measuring the pressure thereof and multiplying the value obtained by the cross-sectional area of the tank. The mass of the water is then calculated by the method described above and the resultant mass subtracted from the total mass. This alternative method has the advantage of not depending on an accurate figure for the density of the oil in order to obtain the mass of the oil.

CLAIMS

1. A method of determining a value dependent upon the amount of a first liquid in a container in the presence of a second liquid having a different relative density, the method comprising determining electrical quantities dependent upon the pressure at or near the bottom of the container due to the liquids, the total depth of the liquids and their densities and using electrical calculating apparatus to calculate the height of the said first liquid from the said determined quantities.

2. A method according to claim 1, further comprising the step of using the apparatus to calculate the volume of the said one liquid from its height and an electrical quantity dependent upon the area of the contained liquid.

3. A method according to claim 2 further comprising the step of using the apparatus to calculate the mass of said first liquid from its density and the calculated value of its volume.

4. A method according to claim 1, 2 or 3 in which the method further comprises the step of using the apparatus to calculate the height of said first liquid by solving the equation

$$h_1 = \frac{P - e_2\,h_T}{e_1 - e_2}$$

wherein h_1 is the height of said first liquid and P, e_1 e_2 and h_T are values as defined in the specification.

5. A method according to claim 4, as dependent upon claim 2, in which the apparatus is arranged to calculate the volume V_1 of said first liquid by solving the equation

$$V_1 = h_1.A$$

wherein A is the superficial area of the contained liquid.

6. A method according to claim 5 as dependent upon claim 3, in which the apparatus is arranged to calculate the mass of said first liquid by solving the equation

$$M_1 = V_1\,e_1$$

wherein M_1 is the mass of said first liquid.

7. A method of determining a value dependent upon the amount of a first liquid in a container in the presence of a second liquid having a different relative density substantially as hereinbefore described.

8. Apparatus for carrying out the method according to any one of claims 1 to 7 substantially

as hereinbefore described with reference to the accompanying drawing.

9. The features as herein disclosed, or their equivalent, in any novel selection.

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